CESM Tutorial: Ocean- and Ice-Model Exercises

Our Note: *this is based on the CESM lab tutorial, downloaded from the cesm web site and then altered for our purpose here. It has not been entirely test-run, and so we will work our way through the process of running ocn/ice cases together on Thursday April 28, 2011, deviating from these instructions as needed. --Matthew Hecht, Elizabeth Hunke and Mathew Maltrud.*

The following instructions will make the most sense to people who are familiar with the CESM User's Guide protocols and terminology. Because you are new CESM users, these exercises are fairly self-contained and include most of the information that you will need. However, as the exercises progress, you may find that you need to look up a detail or two in the CESM documentation. We encourage you to refer to the documentation for complete information on how to create, configure, build, and run the following cases and how to customize the CICE and POP2 models. All guides are available on the CESM1.0 website (http://www.cesm.ucar.edu/models/cesm1.0/)

You may not have time to run all of the following exercises. You should plan to complete the first case, then choose another set that interest you. If you find yourself blasting through all of these exercises and have time to spare, we have included an Advanced Exercises section at the end. We encourage you to try them out while you have volunteers available to help you.

CASE1: Baseline Case

I. **Using this tutorial version of the CESM, based on Sara Rauscher's instructions, create and configure a low-resolution ice-ocean case**. The G compset will produce a case that includes the active ice model (cice), the active ocean model (pop2), and data atmosphere and land models using normal-year forcing datasets. Choose the lower resolution case T31_g37 (there's also T62_g16 for a nominally 1 degree grid) and run create_newcase and configure.

II. **Customize your ice- and ocean-model output.** For some of the example runs described below, we will want to have higher frequency output since interesting changes can happen quickly. Most important for now are globally averaged quantities which require very little disk space. First, cd to Buildconf. Make a backup copy of pop2.buildnml.csh. Open pop2.buildnml.csh and find the namelist diagnostics_nml, then look at the block of commands above it. Note there are only 2 possibilities for diag_freq_opt defined, but we want something in between these. Create a new line in this file that hardwires the value to 'nday'. It is also a good idea to comment this change:

maltrud hardwired daily diagnostic output Apr 28 2011

Our Note: we're leaving the following here so that you can see how to go through this sort of customization of data output, but feel free to just skim through and then run with default output options.

1. In the ocean model, customize your case to produce a new (ie, not set up by default) output file containing a daily averaged timeseries of sea-surface heights. To do this, you would normally follow the instructions in the POP User Guide section titled "Time-averaged history files," but here's a time-saver for you:

```
> $EDITOR $CASE1/Buildconf/pop2.buildnml.csh
```

Find the namelist tavg_nml (search for the string POP2_TAVG_NML_BASE to get there quickly) and then change or add the following variables to the values shown below in bold:

```
n_tavg_streams           =  4
tavg_freq_opt            = 'nmonth' 'nday' 'once' 'nday'
tavg_freq                = 1 1 1 1
tavg_file_freq_opt       = 'nmonth' 'nmonth' 'once' 'nyear'
tavg_file_freq           = 1 1 1 1
tavg_stream_filestrings  = 'nmonth1' 'nday1' 'once' 'SSH.nday1'
```

```
> cd $CASE1/SourceMods/src.pop2
> cp $CCSMROOT/models/ocn/pop2/input_templates/gx3v7_tavg_contents .
> cp  gx3v7_tavg_contents  gx3v7_tavg_contents.orig
> $EDITOR gx3v7_tavg_contents
```

change 1 SSH to 4 SSH

2. To turn on high-frequency, daily output in the sea-ice model, we need to modify some namelist variables in $CASE1/Buildconf/cice.buildnml.csh. In the "setup_nml" part, change the histfreq as follows:

histfreq = 'm','d','x','x','x'

This leaves the monthly stream as the first history stream and adds a daily history stream to the second stream. Once this is added, we need to tell the ice model which variables will go on the daily output stream. This is done by browsing the "icefields_nml" and modifying the variables as follows:

f_aisnap = 'mdxxx'
f_hisnap = 'mdxxx'

This implies that snapshots of ice concentration and ice thickness will be written to both the monthly and the daily output streams. You will find that these variables are already set to the values you want, so you do not need to change them.

III. Run:

1. After a successful build, run the case for 2 months.
2. > xmlchange -file env_run.xml -id STOP_OPTION -val nmonths

```
> xmlchange -file env_run.xml -id STOP_N      -val 1
```

Submit.
2. Confirm that the run was successful by viewing the component model output log files in your $LOGDIR

CASE2: Disable Ocean-Model Tidal Mixing

Our note: If you want to put the effort into configuring some sort of comparison case then this is a good example. We have listed some other possible choices for a cloned comparison case at the end of this Disabled Tidal Mixing section.

Now that you have run a two-month baseline case, you're ready to set up and run your first scientific experiment. To create this "one-off" experiment from your baseline case, use the handy CESM1 script, create_clone. This script will create a "clone" of your baseline case. Repeated use of create_clone will allow you to create a series of one-off scientific experiments.

Recommendation*: It is important to note that unless you are an experienced user, you should not change env_conf.xml in your cloned case. You can do this, but it is beyond the scope of these exercises to walk you through the process.*

I. Create a clone of $CASE1

1. Define your new case name. *Recommendation: organize your CESM cases in a logical, orderly fashion. If you are creating a series of experiments, you might want to set up some sort of case-name ordering system, such as adding a suffix of the form ".nn"*

> setenv CASE2 $MYRUNS/g_1850.01

2. Clone $CASE1
> cd $CCSMROOT/scripts
> ./create_clone -case $CASE2 -clone $CASE1
> cd $CASE2
> ./configure -case

3. ***Recommendation****: add notes to the $CASE2/README.case file. You might add something like this: "This is a clone of the baseline case, in which the ocean tidal mixing is disabled" Note that the README.case file is an exact copy of the $CASE1/README.case file, which is a bit confusing. You might want to add comments to the $CASE2/README.case file to help clarify.*
> $EDITOR $CASE2/README.case

4. ***Recommendation****: Notice that all of your customizations to the ocean and ice build scripts in CASE1, pop2.buildnml.csh and cice.buildnml.csh, have been preserved in CASE2.*

II. Make your science changes in $CASE2

1. Deactivate the ocean-model tidal mixing option. You should check the POP documentation for full information, but for expediency, we'll tell you what you need to do: find the tidal_nml namelist in $CASE2/Buildconf/pop2.buildnml.csh and set ltidal_mixing false.

2. Build $CASE2. Set CONTINUE_RUN FALSE using the xmlchange command or by editing the env_run.xml file. Run the job for five days. Check job status frequently.
> $CASE2/*.build >&! $CASE2/buildout &
> xmlchange -file env_run.xml -id CONTINUE_RUN -val FALSE
and submit again.

3. Check run status. Something went wrong with this case. What is the problem? How would you fix it? Hint: use "ls -lt" to identify the most recent output log files in your run directory.

Some More Ideas for a Cloned Comparison Case

1. Change radiation in ice model
   a. change dEdd shortwave to default (ccsm)
   b. modify the albedos in both (a) cases [dEdd described in original ncar lab instructions]

2. Change dynamics in ice model
   a. change advection from remap to upwind
   b. turn off the dynamics (kdyn=0)

3. Change coupling between ice and ocean
   a. change the turning angle to 25 deg (ice_dyn_evp.F90)
   b. change the depth of currents sent to coupler from POP appropriately for (a)

4. Change the rotation rate of the earth in the ocean model

a. case 4a: double the rotation rate
b. case 4b: halve the rotation rotation rate
c.
d. both of these require modification of POP source code. Find which F90 module by searching for the magic word (what is the 'fictitious' rotational force called?). Copy this F90 file to the SourceMods/src.pop2 directory. Edit this file to double the rotation for one case and halve it for another. Then build and submit. When they are finished, we will look at more than just the netcdf output fields, but also the daily globally averaged diagnostics that we specified by changing pop2.buildnml.csh. Go to the short term archive directory and cd into the ocean model history output directory. Note there are both .nc files and regular text files. Have a look at the *pop.dd.* file which contains time series of numbers including the globally averaged kinetic energy of the ocean (mean KE). Extract just the mean KE from this file using grep. Since the result is not a netcdf file, we can't use ncview, so we'll use gnuplot instead.

5, 6. And then these additional two cases from the CESM tutorial are also useful options, if you didn't like any of the ideas above. So, these additional two options follow:

7, 8, 9, ... And if you don't like any of these options, then read through NCAR's "Advanced Exercises" for more ideas. Or make up your own.

Our note: They caution that this is "not a recommended scientific configuration", that if you had enough time today to run this case for a decade" that problems would appear. This is most likely a reflection of how much time and effort has been put into the the higher resolution x1 components (a lot) and the lower resolution x3 configurations that we're using here (less effort, with priority put on the quality of the fully coupled configuration).

CESM CASE3: Change Ocean-Model Anisotropic Viscosity Alignment

Now that you've experienced a failed science experiment, you're probably ready to set up and run a successful one. Choose either this case or CASE4. In either exercise, you will create another "one-off" experiment from your baseline case.

Remember: It is important to note that unless you are an experienced user, you should not change env_conf.xml in your cloned case. You can do this, but it is beyond the scope of these exercises to walk you through the process.

I. Create a clone of $CASE1. Define a new case name ($CASE3) and clone $CASE1 as in the previous example.

II. Make your science changes in $CASE3

1. Change the ocean-model anisotropic viscosity alignment option. Change the default POP settings to select the alignment option for the parallel component of the anisotropic viscosity. For expediency, here's what you need to do: Find the hmix_aniso_nml namelist in your pop2.buildnml.csh and select the 'flow' option.
The details are in the POP User Guide.

2. Build $CASE3 and run it for two months.

3. Compare your output with the baseline case using tools discussed in earlier tutorial sessions. For quick comparisons, you might use the ncdiff and ncview commands.

CESM CASE4: Change Ice-Model Snow and Sea Ice Albedo

I. Create a clone of $CASE1. Define a new case name ($CASE4) and clone $CASE1 as in the previous examples.
Remember: It is important to note that unless you are an experienced user, you should not change env_conf.xml in your cloned case. You can do this, but it is beyond the scope of these exercises to walk you through the process.

II. Make your science change in $CASE4

1. Change the "snow and sea ice albedo". Note that we are actually changing a more fundamental optical property of the sea ice and snow. Find the R_snw and R_ice namelist parameters in the CICE users guide. The details of these are in the scientific reference guide, but they are essentially a tuning parameter that specifies the number of standard deviations away from the base optical properties in the shortwave radiative transfer code. The albedo that is computed based on these optical properties is nearly proportional to these parameters.

2. First, what sign would you use to decrease the snow albedo? What sign would you use to increase the snow albedo?

3. Let's hit it pretty hard now. Try decreasing the snow and ice optical properties (R_snw and R_ice) by 3 standard deviations each. Set these in the cice.buildnml.csh file.

4. Build $CASE4 and run it for two months.

5. Compare your output with the baseline case.

6. Keep in mind: What time of year did you start your run? Which season do you expect to see the biggest impact for shortwave changes?

NCAR's Advanced Exercises

Here is your opportunity to explore different ice and ocean model options. You might consider the following exercises, or come up with one of your own. Discuss with one of the volunteers if you need help or want some feedback.

Recommendation*: divide up the following exercises within your group, so that together you can cover most or all of these cases and share your results, thereby leveraging your efforts and maximizing your learning.*

1. Set up and run a case in which you double the ice- or ocean-model wind stress. Hint: modify the component model's _comp_mct.F90 file at the point where the model receives the wind stress from the coupler.

2. How would you set up a case to change the sea-ice model shortwave physics back to the CCSM3 formulation?

3. Set up and run a case in which you couple the ocean model every hour and activate the constant short-wave distribution option. You'll need to cut the ocean-model timestep; try a factor of two. What would be the purpose of such a run?

4. Set up and run an ocean-only case in which you turn the overflow parameterization off. You might do this to see the effect of overflows on the Atlantic Meridional Overturning Circulation (MOC). Would the baseline case that you have already run be a suitable comparison case? Why?

5. Set up a fully coupled case with the ocean model on a one-degree grid. What fully coupled compsets are available to you?

6. Set up and run a case in which you change ocean-model mixing coefficients. What are your options? What would you choose to do and why?

7. How would you set up a case to change the pressure formulation in the sea-ice model?